

# Poplar wood for purlins; an evaluation of options and environmental aspects

P. J. Fraanje

The poplar is now applied mostly for low quality products with a short life span. Six options for a higher quality application, in this case a poplar purlin, are presented and semi quantitatively evaluated with regard to their environmental aspects. The options vary from hardly processing the poplar resulting in a roundwood poplar purlin to the intensively processed laminated poplar veneerwood. The least processed options are environmentally most preferable, as the (non renewable) energy input is low, the material efficiency good and the product composition is no barrier to giving the purlin a second life. They require however a more labour intensive forestry and more care in selection and handling than most other options with a more intensive processing of wood. There always will be a fraction of the harvested trees of insufficient quality for the environmentally most preferable options (a roundwood purlin and a rectangular solid wood poplar purlin). In this case the glulam option and the veneerwood option can be environmentally seen interesting. The PLATO-glulam-option can be interesting in situations where dry conditions cannot be guaranteed and is environmentally preferable to the CCA-treated glulam purlin.

## **Pappelholz für Pfetten; Abschätzung der Möglichkeiten und Umweltaspekte**

Pappelholz wird heute verwendet für Produkte von meistens niedriger Qualität mit kurzer Lebensdauer. Sechs Möglichkeiten für höherwertige Verwendung, am Beispiel einer Pfette, werden hier vorgestellt und halb-quantitativ evaluiert im Hinblick auf ihre Umweltaspekte. Die untersuchten Möglichkeiten reichen von einer kaum bearbeiteten Pappel für eine Rundholz-Pfette bis zum intensiv bearbeiteten Furnier. Die Optionen, die am wenigsten bearbeitet sind, haben aus ökologischer Sicht den Vorzug, weil der Energieeinsatz niedrig, die Materialeffizienz gut ist und zudem die Zusammensetzung des Produktes kein Hindernis darstellt, um der Pfette ein zweiten Lebenszyklus zu geben. Man muß aber bemerken, daß für diese Möglichkeiten eine arbeitsintensivere Forstwirtschaft und

mehr Sorgfalt für Auswahl und Handhabung notwendig ist im Vergleich mit den anderen Möglichkeiten. Für die ersten beiden untersuchten Optionen, eine Rundholz-Pfette und eine massive rechteckige Pfette, ist nicht jedes Pappelholz geeignet. In diesen Fällen können Brettschichtholz und auch Furnierschichtholz ökologisch interessant sein. Die PLATO Glulam-Pfette scheint eine ökologisch interessante Option zu sein, wenn trockene Verwendung nicht garantiert ist.

## **1 Introduction**

The poplar (*Populus spec.*) is a well known and fast growing lowland tree. It is planted in vast quantities in the Netherlands, especially as a tree along roads, on dikes and on small lots, often owned by farmers. The Dutch poplar harvest in 1988 was almost 250.000 m<sup>3</sup>, amongst it at least 43.000 m<sup>3</sup> poplarwood of high quality (Dielen, 1991). Poplar wood is now mainly used in so called low quality applications, characterized by a short life span and limited use of the full potential of the resource. Examples of such applications are pallet wood or blocks for transporting building materials, which are commonly used once and are then disposed of. The application of wood in the building sector, especially when used for structural purposes, can be seen as a higher quality application of wood. The Netherlands now import timber from mainly Scandinavian countries, spruce (*Picea abies*) being by far the most important species for construction in the building sector. In theory poplar wood can be used in constructions instead of spruce.

In this article a short review is given of the possibilities of achieving higher quality applications of poplar wood. As an example of a high quality application a purlin made out of poplar is chosen. In this case, more use is made of the resource potential of poplar, as it is applied as a structural component with a long life span. Higher quality application for raw materials like poplar wood can be part of a cascading strategy. Cascading can be defined as the sequential exploitation of the full potential of a resource during its use (Fraanje, 1997). It is supposed that this particular poplar purlin stays dry all throughout its lifetime. The attention is focussed on six different options and their environmental consequences. To determine the environmental impact of the options, a semi-quantitative evaluation is made, on the basis of literature, product information and interviews.

## **2 Life cycle of poplar for buildings**

In Table 1 the life cycle of a poplar building product is shown. There are many possibilities to positively influence the quality of a building product made of poplar. Quality-

P. Fraanje  
IVAM Environmental Research  
University of Amsterdam  
P.O. Box 18180 1001 ZB Amsterdam  
The Netherlands

The author thanks prof. dr. L. Reijnders of the Interfaculty Department of Environmental Sciences (IDES) of the University of Amsterdam for his comments and contributions. I also thank Dr. P. Huybers of the Technical University in Delft and dr. G.S. Orr of the Caledonian University in Glasgow for their comments. I am also grateful to the companies Charpentier Fournier in Le Poiré sur Vie (F), Den Doelder in Axel (NL), de Groot Vroomshoop in Vroomshoop (NL) and PLATO in Wageningen (NL).

**Table 1.** Schematic life cycle of a poplar building product  
**Tabelle 1.** Bilanzschema eines Baumaterials aus Pappelholz

Level	Activity	Result
Plant	F01 selection seed/clone	F07 Poplar tree
	F02 sowing/planting	
	F02 manuring	
	F04 cultivating	
	F05 thinning	
	F06 selection	
Resource	F08 harvesting	F10 Poplar (round) wood
	T09 transport	
Product	P11 handling	P14 Poplar product P16 Poplar building product
	P12 selection	
	P13 processing	
	P15 treatment	
	P17 transport and handling on building site	
Function	B18 application of the Poplar building product	
	B19 structural protection	
	B20 treatment	
	B21 maintenance	
	B22 reuse (to P14) or recycling (to F10)	
	D23 incineration/decay	

F = forestry; T = transport, P = production, B = Building, D = disposal

improvement may vary from finding a clone with good strength-properties for construction (F01), other ways of cultivating (F04), making an early (F06) or better (P12) selection, processing the wood in a certain way (P13) to structural protection of the applied product (B19). In other words, higher quality applications can be achieved not only on resource and product level, but also on plant- and functional level (see Table 1). Current research in the Netherlands is mainly aimed at P13 and P15 (see Table 1) and includes radiation curing of waterborne resin-impregnated wood (COT, 1996), acetylation of wood (Beckers, 1997) and hydrothermal treatment of wood, the so called PLATO-process (PLATO, 1997).

### 3 Selection of options

Six options to use poplar as a purlin are selected to evaluate some of their environmental aspects. The selected options are:

- 1) a roundwood poplar purlin;
- 2) a rectangular, solid poplar purlin;
- 3) a laminated poplar purlin;
- 4) a laminated CCA-treated poplar purlin;
- 5) a laminated PLATO-processed purlin;
- 6) a laminated veneer poplar purlin.

The options are explained in more detail below.

#### 3.1 Roundwood poplar purlin

Poplar wood can be applied as a structural member in buildings, without extra measures, as long as it is protected from moisture and contact with the ground (van Oss, 1950), (Lijdsman, 1954) (Janse, 1979) (Anonymous, 1988) (SHBO, 1995). Poplar roundwood was until the first de-

cades of this century used for building constructions in the country-side of the Near East (Anonymous, 1979). This option also builds on an European research-project "Round Small Diameter Timber for Construction". In the Netherlands roundwood is currently used only in private or restoration building projects. The application of roundwood has an interesting advantage: trees with a relatively small diameter can be used as debarked roundwood which has a much better bending strength than a rectangular piece of wood of the same size (Darby, 1987) (Steer, 1995), as in roundwood the continuous, longitudinal wood fibres are not cut (Steer, 1995). A good selection of the poles is of most importance, as the wood is hardly processed. It should be noted that adaptations have to be made in current building methods when using roundwood for constructions.

#### 3.2 A solid poplar purlin

A good selection of the clone/poplar variety and a good selection of the poplar wood is of crucial importance for this option. In (CTBA, 1984) different suitable poplar-clones are mentioned. A staff member of a Dutch company which produces pallets out of poplar (yearly production at about 30.000 m<sup>3</sup>) declares that his company prefers the Robusta clone for high quality applications to the new faster growing clones; the quality of wood of the latter ones isn't very good (Sinke, 1996). From research in France, it also appeared that among the researched clones the Robusta clone has the best strength-properties (Anonymous, 1988). The earlier mentioned staff member says that sawing 4 metres long purlins of 69×194 mm out of poplar is no problem; his company must however expand the drying capacity, as poplar wood for pallets is usually processed wet. He estimates that up to 40% of the current poplar they process can be used to make a rectangular solid poplar (Sinke, 1996).

#### 3.3 Glulam poplar purlin

In (Colling, 1995) a typical production process for glued laminated timber (glulam) is described. In France (Anonymous, 1988), Hungary (Kaijli, 1977) and former Yugoslavia (Milosavljevic, 1983) poplar is used in a structural glulam beam. Glulam beams of the clone *P. canadensis* of up to 15 m span compare favourably with *Abies alba* beams for house construction (Milosavljevic, 1983). The clone Robusta appeared to be the best clone, to be used for glulam poplar. The strength properties of the beams were comparable to spruce (Kaijli, 1977). Utility buildings have been built successfully in Hungary with glulam poplar beams in load bearing structures (Wittmann, 1976). Glulam poplar was applied in buildings in France in the end of the eighties in pilot projects (Anonymous, 1988). There is one regional company in France that delivers glulam poplar in France, with a production of about 1000 m<sup>3</sup> glulam poplar per year (Fournier, 1996). For laminating the company uses poplar planks of 2 cm thickness glued with melamine urea formaldehyde (MUF) or resorcinol urea formaldehyde (RF), in a quantity of 450–500 gr. per m<sup>2</sup>. Until now their product has mostly been applied in commercial and agro-industrial buildings (Fournier, 1996).

When laminating, more poplars can be used as input in comparison with the first and second option. If naturally grown poplar wood shows a weak spot, this can simply be

sawn and removed. Of a given number of poplars, a higher percentage can be used for glulam. No exact figures were found on these differences in yields. In comparison with rectangular solid poplar the strength properties of glulam poplar are better. This has to do with the elimination of defects in natural timber and the lower degree of variability in strength properties.

### 3.4

#### A laminated CCA-treated poplar purlin

In this case apart from the glue, another additive is introduced: the wood is soaked (or impregnated under pressure) in metal salts to make it more durable. The earlier mentioned firm in France also delivers laminated poplar treated with CCA (copper chromium arsenic) salts (Fournier, 1996). As stated by (Willeitner, 1980), chemical preservation measures should always be preceded by a thorough study of the possibilities of non chemical wood preservation, e.g. structural protection. Treating poplar with CCA-salts for structural components indoors is in fact not necessary: when properly applied, poplar wood is protected from moisture.

### 3.5

#### A laminated PLATO-processed poplar purlin

Though thermal treatment of wood is not completely new – the first publications about trials date back to the 1930s – the PLATO process, developed in 1993 in the Netherlands, seems to be a more sophisticated and operational treatment to make wood more durable. PLATO stands for Providing Lasting Advanced Timber Option. The PLATO-process, consists of three steps; thermolysis, drying and curing. During thermolysis hemicellulose is decomposed and lignin transformed into smaller reactive structures, while the cellulose structure remains essentially unchanged. During the second stage of the process, dry heating results in a reaction of the earlier mentioned reactive intermediates forming a thermosetting resin, penetrating the cellulose fibrous material and producing a rigid structure which retains the appearance of natural wood. This makes poplar as durable as western red cedar; the producer claims that the resistance against decay is greatly improved (PLATO, 1997). Strength-properties do not change substantially in comparison with the untreated wood. The dimensional stability of the wood is enhanced (PLATO, 1997). PLATO makes it also possible to compress and bend wood in the shape which is desired. It is planned that in 1998 a factory will be operational and produce 150.000 m<sup>3</sup> of PLATO-wood per annum (PLATO, 1997). The input for the PLATO-process is in this case, undried sawn poplar wood of a quality comparable to that needed for glulam production. This means that more poplars can be used in comparison with the first two options. The maximum thickness of planks to be hydrothermally treated is about 5 cm, so for the option of a PLATO processed purlin it is also necessary to laminate planks to obtain the desired size (PLATO, 1997).

### 3.6

#### A laminated veneer poplar purlin

A North American firm makes a veneerwood product (laminated strand lumber, LSL), Intrallam-beams, made of wooden chips of young poplars, typically 30 years old when cut, which are glued with polyurethane and processed into a board out of which beams can be sawn (de Groot, 1996) (Schmon, 1997) (Ranta-Maunus, 1995). The

producer claims that young trees from production forests can be used, instead of old growth forests and that 30% more of a log can be used for the processes in comparison with traditional processes. For Parallam (made from thin strips glued together) it is claimed that the company uses as much as 60% more of a log ((TJM, 1997). A laminated veneer poplar is more processed in comparison with glulam or solid natural wood and more glue is necessary in comparison with glulam. Strength properties of laminated veneer lumber (LVL) and laminated strand lumber (LSL) are better than glulam and solid poplar beams. As no data on the environmental impact of Intrallam became available, an European veneerwood production process (Ranta-Maunus, 1995) is used as an example for the evaluation of environmental aspects. The producer of this veneerwood product (made of spruce), has announced that in 1997 a life cycle assessment of the product will appear (KERTO, 1997).

There are differences in forestry method, selection and handling between the first two options and the other four. To obtain good solid poplar wood, which is crucial for the first two options (roundwood purlin, solid wood purlin) it is supposed that the forest management is more labour intensive, more care is taken of individual trees, e.g. they are trimmed in time. For the first two options moreover, selection of suitable poplars takes place in the forest. Only the trees with the desired properties will be cut. It is also preferable that wood obtained in this way is air dried for some months, before it is further processed. This is time consuming, and therefore economically not so attractive, but required for a good quality of the wood.

The other four options studied here are supposed to be performed on a large scale and based on the planting of fast growing clones. Clearcutting is the common harvesting method whereas selection of the wood takes place in the factory. For a complete evaluation of the options involved, these differences should also be taken into account. As more detailed information on differences in forest management and handling is lacking, this is presently not possible.

## 4

### Functional unit for a poplar purlin

To make a proper environmental evaluation of different options a functional unit has to be chosen. A functional unit can be defined as the amount of product necessary to fulfill a function for a certain period of time (Fraanje & Lindeijer, 1994). A purlin of poplar wood has to meet certain standard quality demands, like size, strength, durability etc.

It is assumed that no calamities like leakage of the roof will occur so that the conditions for the purlin are dry and that the natural durability of untreated poplar wood is sufficient. In all wood constructions the untreated poplar purlin can be applied without extra measures. When the poplar wood purlin is used in combination with stone or concrete it is important to protect with paint the ends which are in contact with the wall; in normal building practice this used to be red lead, but from an environmental point of view a high solids paint without lead is preferred. CCA-treated wood and PLATO-wood may be used in this situation without further treatment. It is also assumed that the durability of the glulam poplar and the veneered poplar purlin is comparable with that of the solid wood purlin. In this article the difference in durability is therefore not included in the evaluation.

The average mechanical properties of poplar wood are similar to those of spruce (van der Meiden, 1976) (van der Knaap, 1985). Also (Wiselius, 1992) gives mechanical and physical properties of an average poplar and a spruce which are similar. It should be noted however that there is a great variety of poplar clones with a range of strength properties (van de Kuilen, 1991). Normal lengths of coniferous wooden purlins are 3, 3,6 or 4,2 metres with a size of  $69 \times 194$  mm for a tiled roof of 45 ( $0,7 \text{ kN/m}^2$ ) (Buiten, 1992). In this article, the assumption is made that the strength properties of spruce and poplar are more or less the same and that therefore the rectangular solid poplar purlin has a standard size of  $69 \times 194$  mm.

In normal building practice rectangular solid wood is usually chosen if the sizes necessary are standard. Glulam is chosen when for instance a great span is demanded, while veneerwood is applied if wood of a very high strength is necessary. In future however, this situation can change, e.g. if the availability of wood in certain sizes decreases. Here I assume that the size of the poplar purlin is based on machine grading and that the bending strength determines the size to carry a given load.

It would be preferable to determine all strength properties of the different poplar purlins, but as possibilities are limited, an estimation is made of the relative bending strengths of the poplar purlins. If the bending strength of a solid poplar purlin is put at 1, it can be derived from literature that a roundwood purlin of the same size has a relative bending strength of about 2 (Darby, 1987) (Lukindo, 1997), a glulam (CCA-treated) poplar purlin is estimated to have a relative bending strength of 1,4 (de Vries, 1997) (Peden, 1997) and the value for a laminated veneer poplar purlin is estimated to be 2 (Kalliomäki, 1989) (Peden, 1997), while PLATO-poplar purlins have a relative bending strength of 1 (PLATO, 1997). In theory the roundwood purlin, the veneerwood poplar purlin and the glulam purlins can be designed "slimmer", in other words:

less wood would be necessary per metre to carry the same load. It is assumed in this article that the strength properties are exploited in case of the roundwood, veneerwood and glulam purlin.

Therefore, in this theoretical evaluation of the options for higher quality application of poplar, 3,6 metres long purlins carrying a given load of a tiled roof are evaluated.

## 5 Method

Not enough data are available to perform a complete life cycle analysis (LCA) (method described in (Heijungs, 1992)) to evaluate the options presented in this article. Therefore the environmental evaluation is semi-quantitative. As relevant basic environmental information primary energy-input (E), process-efficiency (R), reflecting the percentage of wood entering the production unit that ends up in the purlin and added chemicals (A) were determined. Energy-input is a good indicator for the fuel use and the emissions related with the production process. Process efficiency is of importance to get a good impression of the overall raw material efficiency of wood-processing. The added chemicals indicate environmental impacts when reusing, recycling or disposing of the product and give information on the possibilities of cascading and the amount of non renewable non fuel resources used in processing.

The energy data are estimates, based on the work of (Bol, 1982) (Ressel, 1986) (Erlandsson, 1994) (Erlandsson, 1996) (Trätek, 1997) and refer to the northwest European situation. Energy data for the PLATO-process were given by the company itself. In the plant that PLATO is going to build, it is claimed that through the combination of two parallel reactors the process energy is reduced. Moreover the company is searching for a location where heat and power generation can be combined (PLATO, 1997). The energy data for PLATO presented here however, do not

Table 2. Calculated and estimated primary energy-input (E), efficiency (R) and added products (A) for standard production steps  
Tabelle 2. Berechneter und geschätzter Aufwand an Primärenergie (E), Effizienz (R) und zugesetzten Produkten für Standard-

		E MJ/m <sup>3</sup>	((re)calculated on basis of) source	R %	source
F01- F08	forestry until harvest	61	(Bol, 1982) (Erlandsson, 1994) (DGfH, 1994)	?	
F06 F08	selection harvest	0 122	Assumption (Bol, 1982) (Erlandsson, 1994) (Meier, 1990)	65	(Hakkila, 1972) (Nilsson, 1976)
T09	transport to sawmill	125	(DGfH, 1994)	100	assumption
P11	air drying wood	0	4 months, watercontent 20%	100	assumption
P12	selection	0	Assumption	90	assumption
P13	debarking	8	(Erlandsson, 1994)	85	(Renia, 1991)
P13	sawing	317	(Meier, 1990) (Ressel, 1986) (Erlandsson, 1994)	55	(Renia, 1991)
P13	kiln drying	1343	(Meier, 1990) (Ressel, 1986) (Erlandsson, 1994)	100	assumption
P13	kiln after air drying	672	Assumption!	100	assumption
P13	laminating Sweden	2527	(Trätek, 1997)		
P13	laminating (incl drying)	3797	(Ressel, 1986) (Meier, 1990), (TrŠtek, 1997)	73	(Ressel, 1986), ratio of sawn wood
P13	laminating ex. kiln drying	2454	Calculated		
P13	veneering	12870	(Ressel, 1986), including drying	56	(Ressel, 1986)
P13	prod. glue (PF/RF)	50	MJ/kg, estimation prod. energy		
P13	planing timber	270	(Ressel, 1986)	83	(Ressel, 1986)
P13	plato total	2450	(PLATO, 1997)	90	(PLATO, 1997)
P13	plato 1 thermolysis	300	(PLATO, 1997)		
P13	plato 2 drying	1725	(PLATO, 1997)		
P13	plato 3 curing	425	(PLATO, 1997)		
P15	preservation	86	(Broens, 1994)	95	assumption

include combined generation of heat and power. Data on efficiency are taken from (Hakkila, 1972), (Nillson, 1976), (Ressel, 1986) (Renia & Sikkema, 1991) and (PLATO, 1997). For some of the processing steps assumptions had to be made. Data on additives were derived from (Trätek, 1997) and from my own calculations.

For every typical process step in the life cycle of wooden products, basic environmental data were estimated. They are given in Table 2.

In Table 3 the options are listed with their estimated environmental impact per m<sup>3</sup>, based on data in table 2.

## 6

### Results

In Table 4 the different options for a high quality application of poplar as a purlin are given per functional unit (3,6 metres long purlin carrying a load of a tiled roof) with their estimated energy-input (E), cumulated material-efficiency (R) and added chemicals (A). The differences in bending strength properties are incorporated in the results, the better the strength properties, the less product is necessary to fulfil the function. The results should be interpreted indicatively.

Table 4 shows that on the basis of available data the veneerwood-option is the most energy-intensive per functional unit wood. Comparison with Table 3 however shows that the differences of energy-input for veneerwood and the rectangular solid purlin per functional unit are not as big as per m<sup>3</sup>. As expected, the energy requirements for the least processed purlins are relatively the lowest.

As far as raw material use is concerned the production of a roundwood poplar purlin is the most efficient. Also the veneerwood purlin and the rectangular solid poplar beam have a relatively good yield. It should be noted that wood which comes off as waste, is normally used for other purposes, e.g. for chipboard production or incineration. It would be useful to take into account quantitatively that

in forestry and wood production per m<sup>3</sup> wood  
Produktionsschritte in der Forst- und Holzwirtschaft pro m<sup>3</sup> Holz

A kg/m <sup>3</sup>	Source
13	(Trätek, 1997), own calc.
60	Own calculation

**Table 3.** Process steps, estimated primary energy-input (E), efficiency (R) and added products (A) for six types of Poplar purlins per m<sup>3</sup>

**Tabelle 3.** Prozess-Schritte, geschätzter Aufwand an Primärenergie (E), Effizienz (R) und zugesetzten Produkten (A) für sechs Pfortentypen aus Pappelholz pro m<sup>3</sup>

Process steps for six options	E MJ/m <sup>3</sup>	R %	A kg/m <sup>3</sup>
F forestry until harvest	61		
F Selection	0		
F Harvest	122	100	
T transport to sawmill	125	100	
P Debarking	8	85	
P air drying wood	0	100	
P kiln after air drying	672	100	
T poplar pole	987	85	0
F forestry until harvest	61		
F Selection	0		
F Harvest	122	100	
T transport to sawmill	125	100	
P Debarking	8	85	
P Sawing	317	55	
P air drying wood	0	100	
P kiln after air drying	672	100	
P planing timber	270	83	
T solid poplar	1575	39	0
F forestry until harvest	61		
F harvest	122	100	
T transport to sawmill	125	100	
P debarking	8	85	
P selection	0	90	
P sawing	317	55	
P laminating	3797	73	13
P glue	650		
T glulam poplar	5080	31	13
F forestry until harvest	61		
F harvest	122	100	
T transport to sawmill	125	100	
P debarking	8	85	
P selection	0	90	
P sawing	317	55	
P laminating	3797	73	13
P glue	650		
P preservation	86	95	7
T CCA-glulam poplar	5166	29	20
F forestry until harvest	61		
F harvest	122	100	
T transport to sawmill	125	100	
P debarking	8	85	
P selection	0	90	
P sawing	317	55	
P plato 1 thermolysis	300	v	
P plato 2 drying	1725	v	
P plato 3 curing	425	90	
P laminating ex. kiln dr.	2454	73	13
P glue	650		
T Plato glulam poplar	6187	28	13
F forestry until harvest	61		
F harvest	122	100	
T transport to sawmill	125	100	
P debarking	8	85	
P selection	0	90	
P veneering	12870	56	60
P glue	3000		
T veneerwood poplar	16186	43	60

**Table 4.** Estimated primary energy-input (E), efficiency (R) and added products (A) for six types of Poplar purlins per functional unit (f.u.)

**Tabelle4.** Geschätzter Aufwand an Primärenergie (E), Effizienz (R) und zugesetzten Produkten (A) für sechs Pfettentypen aus Pappelholz, bezogen auf eine funktionelle Einheit (f.u.)

Type of purlin	Amount of product dm <sup>3</sup> /f.u.	E MJ/f.u.	A kg/f.u.	R %
Poplar pole	24	24	0,00	85
Rectangular solid Poplar	48	76	0,00	39
Glulam Poplar	34	175	0,63	31
CCA-glulam Poplar	34	178	0,96	29
PLATO glulam Poplar	34	298	0,63	28
Veneerwood Poplar	24	390	2,89	43

more poplars are usable for the veneerwood and glulam options in this evaluation, and to see what the overall efficiency is starting from a standing stock of poplar.

The solid poplar purlin as well as the roundwood poplar purlin can be reused in other constructions without any problem. The cascading potential (Fraanje, 1997) of these two options are the best. Untreated glulam wood can also be reused for the same purpose. Recently a company in the Netherlands cleaned and planed glulam wood constructions of petrol stations and used them after resawing in new constructions (de Vries, 1997). However, the presence of adhesive may be a barrier further on in the cascade, when for instance making board from the wood. In amount the veneerwood purlin contains most added chemicals; as long as the glue is phenolformaldehyde, it is not expected that reuse is problematic, though as in case of glulam, there are possibly barriers later on in the cascade, when intending to make board out of a worn out veneerwood product.

The addition of CCA-salts in the CCA-glulam beam is from an environmental point of view problematic. If dumped, such a beam is considered as toxic waste in the Netherlands. When processed for a second life, toxic substances are released. Therefore the possibilities for cascading are limited. The most probable scenario for a disposed CCA-treated purlin would be controlled incineration with energy-recovery. In contrast with the CCA-treated purlin, the PLATO glulam purlin has a cascading potential almost as good as the glulam purlin. PLATO-wood can be normally processed further; after service as a purlin it could for instance be used for window frames. However producing board out of PLATO-wood may present difficulties.

From the indicative results as to environmental aspects of the options studied, the poplar roundwood purlin and the solid poplar purlin are preferable to the other options as the (non renewable) energy input is low, the material efficiency good and the product composition is no barrier to cascading the purlin. For poplars or the parts of the poplar which cannot be used in this way, glulam poplar and veneerwood poplar may tentatively be considered to be good alternatives. The veneerwood poplar purlin needs a relatively high energy investment and should therefore be used only in situations that demand a long span and a high strength. PLATO-treated poplar could be used in situations where dry conditions cannot be guaranteed and is apparently environmentally preferable to CCA-treated poplar.

## 7

### Discussion

There are good possibilities for higher quality application of poplar as strength properties of untreated poplar are

similar to these of whitewood (European spruce). Historical and present examples of structural use of poplar in buildings show good results. It is advised to use untreated poplarwood in dry building construction, e.g. in roofs as a structural component like a purlin or in timberframes etc, as the natural durability of poplar in wet conditions is low.

A Dutch pallet producer estimates that from up to 40% of the poplar they currently process a rectangular solid purlin sized 69\*194 mm and 4 metres long can be sawn. This percentage may be increased when more care is given to clone selection, forestry and handling.

The option of using (small diameter) roundwood deserves more attention in general, as strength properties are very good and the environmental impact is low. Introduction of poplar roundwood in the building sector may nevertheless be problematic. If however some companies could cooperate to make e.g. a ready-to-apply all poplar wood roofing system, consisting of roundwood poplar poles, poplar plywood and a (renewable) insulation material, part of this problem may be avoided.

To further improve the potential of application of poplar with relatively low environmental impact, it is felt that more attention is justified for clone selection, care for individual trees, pruning in time and seasoning the wood. Also better design of wooden building products and structural protection of wood can promote higher quality application of poplar.

There is a remarkable lack of recent, reliable disaggregated data on material-efficiency, energy-efficiency and emissions with regard to forestry and woodprocessing. For this reason, the evaluation in this article of different options for higher quality application of poplar wood can only be indicative. Since environmental data play a more and more important role in the building market, it is in the timber industry's own interest and responsibility to make available transparent and standardized environmental data.

### References

- Anonymus (1979) Poplars and willows in wood production and land use. FAO Forestry series, no. 10, UN Rome
- Anonymus (1988) Le peuplier en structure. CTBA Info, no.19 juillet 1988:7-10
- Beckers EPJ (1997) Ongekende mogelijkheden met geacetyleerd hout. Bouwwereld nr. 3 (10 Feb.):40-42
- Boi MMGR (1982) Energie en energiebesparing in de bosbouw. Ned. Bosb. Tijdschrift 54:166-171
- Boorsma K (1980) Energiebewuste materiaalkeuze Houtvoorzichtingsinstituut; Amsterdam
- Brinks B (1997) Personal communication 3-3-97
- Broens LHA, van der Meulen TS (1994) Levenscyclusanalyse van everbeschoeiingen. van Hall Instituut. Groningen
- Buiten H (1992) Zakboekje Hout; Kluwer Technische Boeken; Deventer/Antwerpen

- Colling F (1995) Glued laminated timber – production and strength classes. In: Blass, HJ (ed.): Timber engineering – STEP 1; Almere (NL): A8/1-A8/8
- COT 1996 (Centre for Research and Technical Advise) information, Haarlem, 8 October 1996
- CTBA 1984 (Centre Technique du Bois et de l'Ameublement). Le peuplier en structure; Paris, 1984
- Darby HJ (1987) Building with home grown round timber. Farm Buildings & Engineering 3:18–22
- DGFH 1994 (Deutsche Gesellschaft für Holzforschung e.V. Holz – ein Rohstoff der Zukunft; München
- Dielen LJM (1991) Hout van eigen bodem: oogst en bestemming. Bosbouwvoorlichting; jrg.30, nr.2, februari 1991:21–25
- Erlandsson M (1994) LCA of building components; KTH, The Royal Institute of Technology; Dpt. of Building Materials; AFR-report 35; Stockholm
- Erlandsson M (1996) Miljödeklaration av trähus – bakgrundsdata; Trätek; rapport L 9606056; Stockholm
- Fournier Charpentes (1996) Le Poire sur Vie (F), written information 14 November 1996
- Fraanje PJ en Lindeijer EW (1994) The quality and the usefulness of the first ten quantitatively oriented product Life Cycle Analyses in the Netherlands; IVAM Environmental Research, University of Amsterdam; Amsterdam
- Fraanje PJ (1997) Cascading of pine wood. Resources, Conservation and Recycling 19 (1997):21–28
- Glos P (1995) Strength grading. In: Blass, H J (ed.): Timber engineering – STEP 1; Almere (NL):A6/1-A6/8
- de Groot F (1996) Schillen, snijden en weer samenpersen. Bouwwereld nr.13 (21 juni 1996):52–53
- Hakkila J (1972) Progress report on the joint Scandinavian program for margin wood resource utilization”. Tappi, no.8, 1972
- Heijungs R (ed.) (1992) Environmental life cycle assessment of products; Backgrounds; CML, TNO and B & G; Leiden
- Heij W (1992) Hout als energiebron; vakgroep Bosbouw LUW; Wageningen, april 1992
- Hoefnagels FET, Kortman JGM, Lindeijer EW (1992) Minimalisering van de milieubelasting van buitenkozijnen in de woningbouw; IVAM; rapportnr.53; Amsterdam
- Huybers P (1990) Thin poles of roundwood for structural engineering applications in buildings. Structural Engineering Review, 2:162–182
- Janse H (1979) Gebruik van hout voor het bouwen in Nederland door de loop der eeuwen heen. Fibula 4/20:6–13
- Kajli L Szarka A Barany A (1977) Testing the suitability of Hungarian timbers for the manufacture of glulam beams for various uses. Faipari Kutatasok 1976/77:29–57
- Kalliomäki J, Kanerva JGW, Hirs H (1989) Kerto-laminated veneer lumber truss; Helsinki Un. of Technology, Dept. of Civil Engineering; Espoo (F)
- KERTO (1997) Ffax Kerto Finnforest, Köln, 12–08–97
- van der Knaap P (1985) Bosuitbreiding en de afzet van populierenhout. Bos & Houtberichten, 1985/11; SBH; Wageningen
- Koponen S, Kanerva P (1992) Summary of European Kerto-LVL tests with mechanical fasteners; Helsinki University of Technology; Espoo (F)
- van de Kuilen JWG (1991) Literatuurstudie naar de eigenschappen van de in Nederland gegroeide douglas, grenen, lariks en populier; TNO-bouw, Centrum voor Houttechnologie; 2063159; Delft
- Lukindo AR, Chastain JP, Janni KA (1997) Review of small roundwood connections; University of Minnesota. Wood Design Focus, volume 8, nr 1 (spring 1997):14–22
- Lijdsman PME (1954) Hout; Kennis van bouwstoffen; deel 1: hout”; Kluwer, 4e dr.; Deventer
- van der Meiden HA (1976) Handboek voor de populierenteelt; KNHM, 4e dr.; Arnhem
- Meier K, Streiff H, Richter K, Sell J (1990) Zur ökologischen Bewertung des Bau- und Werkstoffs Holz. Schweizer Ingenieur und Architekt nr.24, 14 juni 1990:689–695
- Milosavljevic I (1983) Possibilities for using poplar wood in the industrial production of glulam beams for house construction. Zbornik-Radova; Gradevinskog Fakulteta u Beogradu; 1983:43–50
- Narayanamurti D, Handa BK (1953) Acetyliertes Holz. Papier 7 (5/6):87–92
- Nilsson PO, Wernius S (1976) Whole tree utilization – a method of increasing wood supply. Man and the boreal forest; Ecological Bulletins, no.21
- van Oss JF (1950) Warenkennis en technologie; deel I-III, 5de dr.; Elsevier; Amsterdam
- Peden L (1997) The use of new timber composites as an environment-friendly alternative to large solid timber sections; Caledonian University; Fac. of Science & Technology; Glasgow (UK)
- PLATO (1997) Written communication 26–03–97 and personal communications
- Renia HM, Sikkema R (1991) Houtbijproducten in Nederland. SBH; Wageningen
- Ressel J (1986) Energieanalyse der Holzindustrie der BRD. Bundesforschungsanstalt für Forst- und Holzwirtschaft Hamburg (BfH) Hamburg
- Richter K (1996) Ökologische Bewertung von Fensterkonstruktionen verschiedener Rahmenmaterialien (ohne Verglasung); EMPA Abteilung Holz; Dübendorf (CH)
- Sandqvist I, Stridberg S (1985) Sagverken energibalans; STU 82–4287
- Schmon AA (1997) Trus Joist Mac Millan, personal communication 11–03–97
- SHBO (1996) Stichting Historisch Boerderijen Onderzoek, Arnhem
- Sinke 1996 Den Doelder Hout BV, Langeweg 1, Axel, personal communication 15–10–96
- Steer PJ (1995) Timber in construction. Blass, H J (ed.): Timber engineering – STEP 1; Almere (NL) A5/1-A5/6
- TJM (1997) (Trus Joist Mac Millan) on internet: <http://www.stockprofiles.com/tjco/prod.htm>
- Trätek (1997) Environmental declaration Gluelam; Swedish Institute for Wood Technology; Stockholm
- van der Velden A (1997). Sterktesortering van naalddhout – machinaal en visueel sorteren. het Houtblad
- Willeitner H (1980) Möglichkeiten und Grenzen des chemischen Holzschutzes. Holz- Roh- Werkstoff 38:265–268
- Wiselius SI (1992). Houtvademeccum; uitg. Kluwer, 6e druk; Deventer
- Wittmann G, Pluzsik A (1976) New results of the application of glulam load-bearing structures in Hungary. Faipari Kutatasok 1975/76:61–70